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Proposed National Strategies for the Prevention of Leading Work-Related Diseases and Injuries

• Musculoskeletal Injuries •

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Proposed National Strategy for the Prevention of Musculoskeletal Injuries

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Introduction

This document, *A Proposed National Strategy for the Prevention of Musculoskeletal Injuries*, summarizes what actions need to be taken to prevent occupational musculoskeletal injuries. It was developed in 1985 at a conference sponsored by the National Institute for Occupational Safety and Health (NIOSH) and The Association of Schools of Public Health (ASPH), which brought together over 50 expert panelists and 450 other occupational safety and health professionals.

In addition to the strategy for musculoskeletal injuries, NIOSH and ASPH have published strategies for the other nine leading occupational diseases and injuries: occupational lung diseases, occupational cancers, severe occupational traumatic injuries, occupational cardiovascular diseases, disorders of reproduction, neurotoxic disorders, noise-induced hearing loss, dermatological conditions and psychological disorders.

The proposed strategies were originally published in a two volume set, *Proposed National Strategies for the Prevention of Leading Work-Related Diseases and Injuries, Part 1 and Part 2*. These proposed strategies are not to be considered as final statements of policy of NIOSH, The Association of Schools of Public Health, or of any agency or individual who was involved. Hopefully, they will be used in the quest to prevent disease and injury in the workplace.

To learn of the availability of the complete texts of Part 1 and Part 2, or to obtain additional copies of this or other Strategies, contact NIOSH Publications, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Telephone (513) 533-8287.

A Proposed National Strategy for the Prevention of Musculoskeletal Injuries

I. Musculoskeletal Injuries: Problems and Goals

The Surgeon General's Report on Health Promotion and Disease Prevention in 1979 adopted the Canadian Health Fields Model (HFM) as a useful concept for identifying the elements that contribute to death and disease. Four elements were identified:

- Environmental hazards
- Human biologic factors
- Behavioral factors or unhealthy lifestyles
- Inadequacies in the existing health care and ancillary systems

The Surgeon General originally used this model to analyze the ten leading causes of death in 1979. By analyzing the risk posed by each element, the Surgeon General concluded that the prevalence of many diseases could be reduced if the Nation focused on preventive activities; i.e., reducing hazards and avoiding unhealthy lifestyles.

When applied to problems of occupational health, the health field model emphasizes that an individual's illness or injury is the result of several occupational and nonoccupational influences; these influences differ among individuals. The elements can also be applied to work-related musculoskeletal injuries, and each element offers an opportunity for prevention:

A. Environmental Hazards: Hazards to the musculoskeletal system associated with work are described as workplace traumatogens. A *traumatogen* is defined as a source of biomechanical stress stemming from job demands that exceed the worker's strength or endurance, such as heavy lifting, or repetitive, forceful manual twisting. Traumatogens can be measured by determining the frequency, magnitude, and direction of forces required in relation to body posture and the point of application.

B. Human Biologic Factors: These include the anthropometric or innate attributes that influence a worker's capacity for safely performing the job. Examples include the worker's physical size, strength, range of motion, work endurance, and the integrity of the musculoskeletal system. These factors partly account for variability in performance capability in the population and the potential mismatching of worker and job. Hence, when job demands habitually exceed the worker's capacities as defined by such physical attributes, the health and safety of the worker are compromised.

C. Behavioral Factors or Unhealthy Lifestyles: This element refers to acquired behaviors or personal habits that increase the worker's risk of incurring musculoskeletal strain or injury. Such behavioral factors may include insufficient sleep or recovery from exertion, the perception of the job as being excessively demanding or hazardous, job dissatisfaction, and mental lapses due to response interference. Lifestyle factors can include obesity or lack of adequate physical fitness, unhealthy diet, and substance abuse either during or outside work. Recent studies have also focused on personality factors predictive of permanent disability.

D. Inadequacies in the Existing Health Care and Ancillary Systems: These factors include a lack of medical knowledge and appropriate training for health care personnel on the etiology, diagnosis, and treatment of musculoskeletal problems that result from biomechanical strain. Management, design engineers, and workers need special health and safety training in recognizing traumatogens and in understanding the role of biologic and behavioral risk factors for musculoskeletal injuries. Such groups would also benefit from training in the principles of prevention and health promotion.

II. Conditions to be Addressed

The National Institute for Occupational Safety and Health (NIOSH) has identified work-related musculoskeletal injuries as one of ten leading occupational health problems affecting workers. Musculoskeletal injuries as considered here encompass both acute and chronic injury to muscles, tendons, ligaments, nerves, joints, bones, and supporting vasculature; injury is understood as a component of the overall classification, disorder. Descriptive examples of the term injury include sprains, strains, inflammations, irritations, and dislocations. In contrast, mishaps resulting in injuries in which the skin or bones are broken, such as from the transfer of high energy, are defined as traumatic injuries. These occupational traumas are the subject of the Proposed National Strategy for the Prevention of Severe Occupational Traumatic Injuries.

Injury resulting from exposure to continued trauma is often defined according to the structure thought to be inflamed, irritated, or strained, for example, tendonitis, synovitis, bursitis, nerve entrapment, and lumbar pain. Collectively these terms are applied to a broad class of physical symptoms or complaints that are commonly labeled in the medical literature as wear-and-tear disorders, overuse injuries, osteoarthrosis, degenerative joint diseases, chronic microtraumas, and cumulative trauma disorders.

Because few of the musculoskeletal injuries that stem from exposure to long-term trauma are universally accepted as uniquely occupational in origin, defining a work-related musculoskeletal injury often depends on identifying a hazardous antecedent condition in the workplace.

Much remains to be learned about the causes for work-related musculoskeletal injuries. A current theory holds that continued exposure to excessive physical stress accelerates the onset or aggravates the course of regional musculoskeletal injuries. Indeed, the sources of the high physical stress can often be traced to ordinary work activities that include repetitive or sustained lifting, bending, twisting, climbing, reaching, gripping, pinching, rubbing, kneeling, and squatting as well as vibration from equipment. Moreover, these activities are often performed in awkward postures and involve high forces. When the job demands inherent in these activities repeatedly exceed the biomechanical capacity of the worker, the activities become trauma-inducing. Hence, traumatogens are workplace sources of biomechanical strain that contribute to the onset of injuries affecting the musculoskeletal system.

The difficulty in discovering the etiology of this class of regional musculoskeletal injuries parallels the difficulty in defining the mechanism responsible for the symptoms. One notion is that the accumulated microtrauma caused by repetitive motion can set up a symptomatic inflammatory response, which may in turn be responsible for the symptoms and the restricted motion associated with aging. Furthermore, if the accumulated microtrauma is not given enough time to heal, a secondary risk of tissue failure may result. This process may account for conditions such as tendon ruptures or even stress fractures. Similar outcomes may occur in response to single traumas or to a few exposures to extremely high levels of biomechanical stress. Such postulates, however, are heuristic when applied to many common regional musculoskeletal injuries where no demonstrably pathoanatomic abnormalities can account for the symptoms. Regardless of the cause, abnormal anatomy, physical fitness, previous injury, or age-related changes can also alter one's physical capacity and thus can contribute to the injury.

III. Scope of the National Problem

Our present knowledge of the national scope of work-related musculoskeletal injuries is clearly inadequate, providing at best a limited and fragmented view of the extent of such problems. A main reason is that current estimates of the problem have been extracted from existing data bases that were not designed for the surveillance of occupational musculoskeletal injury. As such, the existing reporting systems confound occupational- and nonoccupational-related disorders, fail to differentiate chronic and acute injuries, and lack standard terminology and diagnostic criteria for defining cumulative trauma-related musculoskeletal disorders.

Despite the absence of accurate national prevalence data, there is a growing awareness among researchers and practitioners that musculoskeletal injuries account for a highly significant amount of human suffering, loss of productivity, and economic burden to the country. Support for these views comes in part from the following sources:

- Musculoskeletal injuries are the leading cause of disability of people in their working years, afflicting 19 million persons (National Center for Health Statistics, Health Interview Survey, 1977). High risk industries include manufacturing, construction, and food processing. Nearly one-half the Nation's workforce are affected at some time during their working life.

- Musculoskeletal injuries rank first among health problems in the frequency with which they affect the quality of life, as indicated by the extent of activity limitation (National Center for Health Statistics, Health Interview Survey, 1977).

- The cost of musculoskeletal injuries, based on lost earnings and worker-compensation payments, exceeds that of any single health disorder. Low back problems alone cost American industry an estimated $14 billion per year (1976).

- Musculoskeletal injuries account for one-third of annual worker compensation claims. Claims for sprains and strains are the most prevalent—with the back accounting for almost 50 percent of such disorders—followed by disorders of the ankle, knee, and shoulder.

- Musculoskeletal injuries also represent a significant accessory or causal factor in a large number of acute traumatic injuries.

- The frequency and impact of musculoskeletal conditions on the workforce are expected to increase over the next several decades as the average age of the workforce increases.

A projected increase in musculoskeletal injuries and disorders is already evident despite the move toward more sophisticated automation and the shift away from physical to mental work, for example, processing of information and service-related jobs. Remarkably, the introduction of modern office technology, such as computers, video display terminals, and optical scanners, designed to reduce physical labor, has generated claims of new, pervasive, and even more insidious sources of biomechanical stress to the musculoskeletal system. The majority of these claims are attributed to chronic repetitive motion and static and constrained postures. The magnitude of these problems is only now beginning to emerge.

IV. Potential for Prevention and Control

Prospects for reducing work-related musculoskeletal injuries depend on progress in four methodologic areas.

- Identifying accurately the biomechanical hazard.

- Developing effective health-promotion and hazard-control interventions.

- Changing management concepts and operational policies with respect to expected work performance; i.e., working smart, rather than working hard.

- Devising strategies for disseminating knowledge on control technology and promoting their application through incentives.

A. Determining the causes of musculoskeletal injuries continues to be problematic, as with all disorders associated with trauma and aging. This difficulty results partly from the complexity and number of potential etiologic factors, the long latency periods, and the interaction with the effects of aging. Moreover, no standardized set of diagnostic criteria and techniques or medical signs and symptoms is yet available to reliably identify many of the disorders. More vigorous and focused longitudinal research is needed to identify occupational and nonoccupational causes.

B. Developing interventions has a practical, problem-solving focus. The recommended interventions for reducing work-related musculoskeletal injuries involve an engineering approach; i.e., redesigning the work process or tool to impose less

biomechanical stress. Without complete information on causes, reasonable assumptions must be made based on biomechanical models of physical trauma so that answers to problems can be tested by judging both their feasibility and effectiveness.

Information is already available from ergonomics and allied fields to suggest that many of the biomechanical hazards associated with occupational musculoskeletal injuries could be eliminated if such knowledge were put into practice. Field validations of biomechanically based prevention strategies are needed to determine those that work.

C. Changing management concepts of productive work is important because managerial concepts and practices often become main contributors to musculoskeletal injuries. Many jobs enter the high-risk category because demands for production put pressure on supervisors to "get things moving." Like football coaches, many managers are convinced that a 125 percent effort is better than an 85 percent effort. However, this work ethic may not be valid for certain tasks. Managers who establish operating policies, such as "working smarter is better than working harder," in the worker's mind, may most effectively maintain production levels by reducing lost time due to worker injuries. However, unless workers understand this policy, little chance exists to improve the cautionary responses needed for prevention.

D. Dispensing and applying accumulated knowledge is essential for overcoming resistance to change and reconciling the initial costs of proposed interventions with anticipated long-term benefits. The disparity of backgrounds of key professional people who must cooperate in advocating and evaluating interventions must also be overcome. For example, in the musculoskeletal area most engineers are not trained in ergonomics or biomechanics and health care personnel are not knowledgeable about manufacturing technologies, yet they must work together. The problems in cooperation common to all health and disease-prevention programs are now being recognized as most formidable and potentially the chief roadblock in any prevention-oriented program. Probably the most direct approach to this issue is to fund targeted, controlled, intervention trials. Resistance to change might fade in the face of substantial data.

Despite these difficult issues, the Nation cannot ignore this growing occupational health problem or the significant volume of information on musculoskeletal injuries emanating from such fields as biomechanics, clinical research, and ergonomics. Hence, a first national strategy is offered for preventing or reducing the incidence of work-related musculoskeletal injuries and disorders.

V. Addressing Broad Tactical Areas of a National Strategy for Prevention

A. Refining Surveillance Systems

1. Health Surveillance

Strategies designed to prevent or mitigate musculoskeletal injuries require sensitive and verifiable surveillance schemes for identifying and reporting specific musculoskeletal conditions. Such systems should provide an analysis by occupation to target those occupations that display disproportionate incidence. New occupations and emerging technologies in which workers may be at risk from exposure to unprecedented biomechanical stresses also need to be identified.

Existing data clearly indicate major deficiencies in surveillance systems for identifying work-related musculoskeletal injuries. Because existing data sources were not designed for surveillance of occupational musculoskeletal injury, they do not separate chronic from acute injuries, and they lack a standard terminology for defining the acute and chronic medical conditions in general.

2. Hazard Surveillance

Coupled with needed refinements of health surveillance is a similar need for improved surveillance to define the types and ranges of biomechanical stresses that exist in the workplace. The ultimate value of hazard surveillance lies in prevention because it can provide an early warning of potential cumulative trauma.

Hazard surveillance would make use of ergonomic-type surveys, worksite inventories, or biomechanical profiles of various job conditions to identify the types of biomechanical job demands that pose a risk of musculoskeletal injury. Evidence of workplace-related hazards is particularly important because the hazard may be the only reliable way of classifying a musculoskeletal disorder as work-related.

Without some form of workplace data to identify the presence of biomechanical stress, nonspecific chronic health symptoms, such as joint pain and loss of mobility, may be incorrectly diagnosed as nonoccupational and go unreported. In addition to the obvious value for enhancing the validity of surveillance data, information on sources of biomechanical stress for a given occupation can be used to build models that predict the occurrences of musculoskeletal injuries.

3. Essential Elements for Surveillance of Occupational Musculoskeletal Injuries

a. Guidelines should be set for data collection and diagnostic criteria established for classifying all musculoskeletal disease conditions experienced by workers, whether job-related or not. Definitions should be standardized for characterizing discomforts, injuries, and hazards.

b. Objective criteria should be determined to differentiate occupationally from nonoccupationally related disorders. The system should also identify the methods of reporting.

c. Multilevel data bases at national, state, and local levels should be established and supplemented with specific longitudinal epidemiologic evaluations. Multilevel recording is important because the long induction periods for many of the musculoskeletal injuries separate the hazard from the effect. A multilevel health reporting system could track health status across jobs, across geographic relocations, and through retirement.

In general, a positive byproduct of an effective surveillance program would be the renewed awareness within the medical community of the prevention benefits to be derived from a standard reporting system. Such a system would also assist occupational health providers in correctly diagnosing, recording, and treating musculoskeletal injuries.

Recommendations for improving surveillance systems are given in the section on Action Plan.

B. Evaluating Cause and Effects

1. Coordinating Scientific Disciplines

Ultimately any effective strategy geared to prevention must be based on a firm grasp of the factors responsible for the targeted disorder. Analysis and evaluation of relevant surveillance and clinical data are required to uncover the key occupational and nonoccupational risk factors.

For musculoskeletal injuries, the evaluation stage in the prevention process requires the coordination of research in several disciplines encompassing both basic and applied approaches. For example, health professionals should be encouraged to work with engineers and scientists to develop research programs that incorporate each specialty in the design and implementation of an intervention. Once an intervention is designed, hardware manufacturers and users should be brought into the process to fabricate and disseminate new, ergonomically designed equipment, tools, and workplaces.

One of the more pressing needs is for studies that examine the patterns of interacting variables. Methods and measurement techniques also need standardization and better documentation to allow adequate verification and validation so that practitioners can benefit from the development.

2. Causes of Low Back Pain

Evaluating the etiology of low back pain is particularly difficult. Much of what is known about the risk factors for low back injury is based on epidemiologic data. Two categories of factors that modify the risk of injury have been differentiated from recent surveillance efforts: factors associated with the job and personal factors. Job risk factors include load weight, location, and frequency of materials handling, but often go beyond task design to include psychologic factors. Personal factors emphasize age, gender, and strength, but the significance of other personal factors such as fatigue, postural stress, trauma, emotional stresses, degenerative changes, congenital defects, genetic factors, neurologic dysfunction, physical fitness, and body awareness should also be evaluated. The list is far from complete. These personal factors in combination with primary job risk factors make determination of the cause of low back disorders most formidable.

Nevertheless, research on low back pain has progressed beyond the stage of identifying risk factors to include evaluations involving dynamic and 3-dimensional modeling and laboratory confirmation. Improved techniques are now needed for estimating tissue forces and pressures noninvasively, both in the laboratory and on the job. Such techniques are necessary to evaluate the stress patterns induced during manual materials handling and to determine to what extent they could be eased through varying different load factors or lifting techniques.

3. Causes of Extremity Disorders

Some progress has also been made in isolating key sources of work-related

biomechanical stress for the upper extremities. Biomechanical analyses of hand and arm motions have been useful in specifying points of stress related to symptoms of carpal tunnel syndrome and tenosynovitis. Repetition rate, amount of force required, and postural factors emerge as contributors to these injuries.

In contrast, research on occupational injury of the lower extremities has been limited almost exclusively to the knee. Potential sources of biomechanical trauma to the knee that have been identified include repetitive loading, constant kneeling, squatting, and repetitive contact between the knee and specialized tools.

In general, continued research is needed to combine anatomic, mechanical, physical, and human factors in describing work populations by their abilities to work on a given task without injury. These profiles would provide guidelines for designing new jobs and tools to protect the limbs and joints from excessive biomechanical stress.

Recommendations for improving our understanding of causal mechanism are listed in the Action Plan.

C. Controlling Occupational Risk Factors

Three approaches are used for intervention in jobs in which high physical demands pose a risk to the musculoskeletal system.

- Redesign the job or tools so that demands can be met by a majority of the population.
- Train workers in techniques to reduce job hazards; i.e., how to lift and how to avoid awkward postures and repetitive motions.
- Select only those individuals whose work capabilities meet or exceed the high demand.

1. Ergonomic Job/Tool Redesign

a. Operating Principle

The use of engineering techniques has been a basic tenet of occupational safety and health practice for achieving hazard control, in preference to other methods, such as personal protective equipment and safe work practices, which are less reliable and often less effective. The engineering procedure involves modifying task and tools using ergonomic principles to reduce the effects of biomechanical stress.

Unlike the majority of occupational hazards, sources of biomechanical stress seem hidden within the job as specialized patterns of movement or tool use. The relative obscurity of the hazards necessitates that controls be designed into each job identified as having a high risk of musculoskeletal injuries.

This ergonomic approach is based largely on the assumption that work activities that involve less force, repetition, vibration, weight, and forms

of static or constrained postures are less likely to cause injuries and disorders. The approach is desirable because it seeks to eliminate potential sources of problems. Ergonomics also seeks to make safe work practices a natural result of the tool and worksite design without depending on specific worker capabilities or work techniques.

b. Difficulties Associated with Ergonomic Interventions

The use of ergonomics in job and tool redesign is still in its infancy, largely because an awareness of the science is lacking and not enough cases have been documented showing the effectiveness of these techniques.

However, a few recent demonstration studies have shown reductions in biomechanical stress with ergonomically designed tools, such as the contoured hand grip on pliers for electrical wiring and the specifically shaped knife for poultry processing. Controlled intervention trials are also needed to demonstrate actual reductions in the prevalence of symptoms and injuries.

Initial economic considerations combined with the lack of sufficient substantive evidence for effectiveness have dissuaded many industries from implementing job redesign that might result in reduced injuries and lost work time and ultimately in potential savings.

In contrast, some industries, when faced with staggering workers' compensation costs and rising disability insurance premiums (e.g., those tied to back injuries from manual materials handling), have been motivated to seek out and implement ergonomic solutions. Some have found ergonomic job redesign an effective adjunct to cost-reduction programs. Analyses often demonstrate that ergonomic intervention can reduce musculoskeletal injuries and also contribute to increased productivity. In addition to decreased medical costs, reductions in lost time from injuries and increased worker productivity can be compelling reasons for adopting an ergonomics program. Equally important, ergonomics can form the basis for an improved quality of work life.

c. Design Principles

For some sources of biomechanical stress, implementing an effective ergonomically based recommendation may be difficult. For example, different overlapping sources of biomechanical stress (e.g., vibration, repetition, load, and posture) may contribute in some unknown way to the onset of musculoskeletal disorders. Often no simple, single change can be made, but numerous adjustments may be required to tailor recommendations to the tool, workstation layout, or organization of the task.

2. Worker Training/Good Work Practices

The success of training programs in reducing musculoskeletal injuries has been mixed. Programs in this area range from rudimentary instruction of workers about safety rules and "how to lift," to elaborate programs conducted by Educational Resource Centers (ERCs) for instructing safety and health personnel in the types of neuromuscular disorders associated with repetitive motion.

Studies that evaluate the effects of training in reducing the back injuries associated with lifting have produced conflicting results. One of the most comprehensive and widely reported studies found no evidence that training had any preventive effect. This finding contrasts with the results of a study evaluating training in materials handling for railway workers, which showed annual decreases in the rate of back injury. The training system was developed in cooperation with a rehabilitation clinic. Similarly studies of "work hardening" or physical conditioning programs designed to improve trunk and leg muscle strength for preventing back injuries have largely failed to confirm the long-term efficacy of the programs.

Efforts are under way in some industries to broaden the training beyond the fundamental issues of safe work practices to include the following:

- Recognition programs for increasing worker awareness of the hazards.
- Problem-solving programs designed to provide workers with the information and skills necessary to participate in hazard control activities.

Many of these more comprehensive training programs have been supported jointly by management and worker organizations. The federal government has provided some limited assistance in grants from the Occupational Safety and Health Administration (OSHA) as part of their New Directions program.

Such worker training programs are believed to be effective in reducing job-related injuries, but available data needed to evaluate such programs are limited, particularly with respect to preventing disorders.

Training and education of professional safety and health personnel is provided in part by NIOSH, especially through its funding of ERCs. The impact of this training is also difficult to gauge in terms of directly reducing musculoskeletal injuries and illness. The ERC program, however, and its ergonomic and musculoskeletal components have stimulated an increased awareness among occupational health professionals of the basis for occupational musculoskeletal injuries. ERCs have also served the local communities as resources for information and guidance in implementing workplace interventions for controlling such injuries.

Thus, training programs have traditionally focused on teaching employees specific work practices for safety and hygiene. Although most experts support such training, the preventive utility has been difficult to evaluate. The concepts of training have been extended recently to include elements of recognition and problem solving. Moreover, education aimed at awareness is now recognized as necessary at all levels of management, including staff specialists, such as tool and workplace designers and engineers.

3. Selection/Placement

Employment screening for musculoskeletal injuries has been used to predict the risk of low back disorders. Selection procedures include anthropometric attributes, such as weight and stature, and the use of back radiographs, muscle strength tests, tests of physical fitness, and tests of lumbar mobility.

The success of any screening program requires accurate information on actual job demands as well as precise measurements of worker capacities related to the key job demands. For example, muscular strength is generally considered an appropriate job-related criterion for work involving manual materials handling. However, measuring the capacities of a worker that most closely reflect the key strength requirements of the job is difficult. Moreover, strength measures are sensitive to many psychologic variables, including motivation, expectation, and fatigue tolerance. Studies in which appropriate measurements have been made show a higher incidence of claimed back injuries and back pain in those jobs demanding high exertion in relation to the worker's own maximal isometric strength.

In contrast, the use of anthropometric guidelines for selecting workers has not been justified in studies of manual materials handlers when the outcome was measured in incidence rates for the reduction of low back pain. Although radiologic measurements have been largely discredited as a screening procedure for back problems, they are still widely used. Caution is urged to avoid a potential radiation hazard from overuse. In theory, the assessment of job demands for work output offers a valid alternative for reducing the incidence of musculoskeletal injuries. In practice, this approach is difficult to implement because of the wide variety of demands inherent in the manual jobs of most industries, the range of individual physical capacities, and the lack of criteria for safely matching workers to jobs.

Thus, the ergonomic approach to workplace redesign may be the first choice for controlling musculoskeletal problems, with employee selection and training secondary. Several reasons for this priority exist.

a. Selection and training require that each new employee be evaluated, instructed, and thereafter monitored to determine changes in capacity and compliance with the training procedures. In contrast, health promotion programs combined with ergonomically sound jobs and tools are relatively permanent, and, once implemented, do not normally require modification for each new employee.

b. Employee screening and selection techniques discriminate those considered fit for the job from those who are not. Fitness for a job must therefore be based on actual job demands, which are often difficult to assess. Caution must be exercised that selection procedures are specific to the job, and the general criteria of selecting only the strongest or youngest workers must be avoided.

c. Although training programs are easily implemented and may initially appear less costly than other forms of intervention, they can be more expensive over time because each new employee must be trained and then periodically given a review.

Recommendations for improving our ability to devise effective interventions are provided in the Action Plan.

D. Increasing Awareness and Stimulating Interventions

1. Obstacles to Implementation

The success of any prevention strategy ultimately depends on the potential for implementation. Implementation may be facilitated by increasing both public and professional awareness of the causes and effects of musculoskeletal injuries and by establishing and then conveying an effective rationale for implementing ergonomic or other solutions to these problems. It is difficult, however, to determine the most effective means of getting the information to the public, and how to best use existing communication networks.

2. Need for Effective Communication Models

Effective communication is particularly important when the subject involves changing attitudes and behavior. The targets of such communication are either individual workers or organizations (including unions and management or both). Various means of disseminating occupational health information have been proposed, ranging from contracts with local physicians to in-plant clinics or comprehensive health maintenance organizations with occupational health specialty services. Sponsors could include corporations, unions, private practitioners, foundations for medical care, independent medical organizations, and local and state governments.

3. Dissemination Needs

Several dissemination needs can be identified. One pressing need is the provision of ergonomically trained personnel at regional levels such as state health departments, industrial commissions, or similar entities (ERC's) who could offer technical assistance on musculoskeletal disorders to employers and employees. Because only two or three centers of ergonomics currently exist in the United States, the number of regional centers should be increased to provide outreach service and education to local employers. The number and quality of special ergonomic and musculoskeletal courses in regional universities also need to be increased. The number and quality of specialized courses to help workers and employers identify acute and chronic musculoskeletal risk factors should be expanded and the necessary training provided for them to devise their own prevention strategies.

A best method has not yet been determined for increasing the awareness of the musculoskeletal problems within small businesses. A significant number of businesses in the United States employ 25 or fewer workers. These small businesses rarely provide occupational safety and health services, and employers and workers may not recognize the special musculoskeletal health problems created by biomechanical stress.

More in-depth courses on occupational medicine and specific treatment should be included in medical school curricula. The NIOSH Minerva project in the ERC's should continue to encourage the inclusion of occupational safety and health subjects, such as ergonomics, in the curricula of schools of business.

Finally, user-oriented guides for prevention and control of cumulative trauma should be disseminated to workers identified through previous surveillance as being in high-risk jobs.

Other dissemination issues involve defining the role of computer technology and telecommunication networks. How should this technology be used to make information about hazards and potential ergonomic solutions more

readily available? What type of public service messages would be effective? What role should occupational and professional organizations play in alerting the public to risk factors for osteoarthritis and to the potential preventive measures involving physical fitness?

Several issues and needs have been outlined. A series of recommended actions for dissemination are proposed in the Action Plan as a first step toward addressing these issues and meeting the identified needs.

VI. Action Plan

Progress in preventing musculoskeletal injuries depends on the cooperation and availability of trained health professionals who are knowledgeable about the nature and extent of musculoskeletal problems in the workplace. Moreover, these trained health professionals must be able to educate workers and employers about risk factors and to assist them in implementing effective control procedures for prevention. Thus, priority for action is based on (1) establishing a coordinating body, (2) educating health professionals and scientists, (3) improving surveillance and research information, (4) developing and evaluating effective interventions, and (5) disseminating information to the public. Recommendations to be implemented immediately are followed by those to be implemented in the near future.

A. What Can Be Done Now

1. Coordinating Body

Establish a National Committee for Occupational Musculoskeletal Disorders to lead a national effort for preventing musculoskeletal injuries; the magnitude and nature of the musculoskeletal problem require input from an expert committee. The composition of the committee must be multidisciplinary and representative of industry, labor, academia, professional groups, and government.

a. The committee would function as an advisory body to assist in coordinating national efforts in research, training, and prevention.

b. The committee would also promote clinical and scientific consensus related to:

- Definitions of occupational musculoskeletal injuries
- Diagnostic criteria for musculoskeletal injuries
- Uniform surveillance terms and outcome criteria

2. Training/Professional

Train more clinical personnel in the etiology of musculoskeletal disorders and train more design engineers in biomechanics and ergonomics. This could be accomplished at the regional ERCs and at research centers or clinics that are conducting research in the control of musculoskeletal injuries. Any necessary curricula and training standards should be developed by professional societies.

3. Training/Grants

Establish post-doctoral grants and research assistantships to encourage young investigators to seek advanced training in the prevention of musculoskeletal injuries. Such grants would provide opportunities for recently graduated clinicians and scientists to conduct research under the guidance of experienced senior investigators in occupational biomechanics, kinesiology, epidemiology, industrial rheumatology, ergonomics, and related fields.

4. Training/Workers

Promote worker training programs to emphasize musculoskeletal problems and the need for control. Assuming that the risk of musculoskeletal injury is influenced by industrial behavior, the thrust of the programs should be to encourage workers to participate in the redesign of jobs, tools, and workstations.

5. Education/Awareness

Encourage labor and management to explore new ways of informing workers about sources of biomechanical stress in their job and to explore ways of informing workers about available preventive measures that control the trauma. Programs should be conducted to show successful models.

6. Prevention/Education

Recognize that the occupational nurse is often the first-line link between the worker and health professionals in the community. Hence, nurses should be integrated into occupational health programs concerned with musculoskeletal injuries where they can serve as catalysts and coordinators in promoting musculoskeletal health and preventing disease.

7. Education/Science

Promote active interchange of scientific information. The proposed National Committee on Musculoskeletal Diseases, with sponsorship from private and government sources, would develop agendas for symposia and workshops on topics of basic research for evaluating the causes and effects of musculoskeletal injuries and the means for their prevention.

8. Surveillance Functions

Develop innovative musculoskeletal surveillance systems to improve our understanding of the nature, extent, and magnitude of the problem. NIOSH should place special emphasis on conducting longitudinal studies in cooperation with management, labor, and universities.

9. Research Mechanisms

Promote more research on etiology and prevention procedures through the use of grant mechanisms involving initiatives from NIOSH and the National Science Foundation for research on musculoskeletal injuries at the workplace. This may include the need to consider peer review of research grant applications. Consider establishing a list of standing reviewers to respond to

grant applications that involve areas outside the expertise of the existing study section.

10. Research Topics

Focus research priorities on definitive studies for assessing the relation between an injury or disorder and the particular job task. Such research areas could include:

a. Determining prospectively whether the pattern of musculoskeletal use influences the pattern or the symptoms of the musculoskeletal injury. Determining whether use makes an underlying disease manifest by precipitating symptoms.

b. Determining which biologic or anthropometric attributes influence the onset and course of acute and chronic musculoskeletal injuries.

c. Determining the role of behavioral and lifestyle factors, such as work expectations, loss of sleep, unhealthy diets, or lack of adequate physical fitness, as risk factors for musculoskeletal injuries.

d. Conducting disease studies to determine whether a particular pattern of musculoskeletal use results in a particular pathoanatomic derangement.

e. Developing and evaluating clinical screening procedures that improve existing methods of worker classification to match workers to jobs that do not exceed the worker's capacity.

f. Conducting basic research in biomechanics to validate and enhance existing biomechanical models that further an understanding of the underlying etiology of occupational musculoskeletal injuries and their prevention.

11. Prevention/Evaluation

Provide financial and staff assistance through a grant mechanism to state and local health agencies, universities, and community health groups that prepares them to perform workplace evaluations, consisting of the following activities:

a. Conducting epidemiologic studies to identify workplace traumatogens.

b. Conducting controlled intervention studies (Phase 3-type) to establish the efficacy of proposed countermeasures and prevention strategies.

c. Conducting demonstration studies in select, high risk industries.

12. Dissemination

Define an implementation/dissemination model for preventing musculoskeletal injuries that includes the following elements:

a. Identifying target groups; i.e., workers, employers.

b. Identifying type of messages; i.e., awareness of problems, information on solutions, where to find assistance, and benefits of prevention procedures.

c. Identifying the most effective medium for target group.

d. Developing evaluation procedures for feedback on the effectiveness of dissemination programs.

e. Developing an overall marketing plan to direct the dissemination of prevention strategies for musculoskeletal injuries.

13. Dissemination/Awareness

Use public service information programs and the media in collaboration with societies that represent health professionals to educate clinicians, industrial leaders, and the worker to the true costs of musculoskeletal injuries, in terms of both economics and human suffering. Provide education on the causes, risk factors, prevention, and treatment of disorders associated with occupational musculoskeletal injuries (e.g., carpal tunnel syndrome, office ergonomics, and the use of video display terminals).

14. Prevention/Implementation

Establish a closer liaison between local health services, community health groups, and industry. This could be accomplished with support from a regional ERC. This liaison could be facilitated by the appointment to regional ERC faculties of local specialists in occupational medicine. Emphasis should be given to reaching small business and industries. Small business should be assisted in establishing an ergonomic network to share information on musculoskeletal problems and potential solutions.

15. Education/Awareness

Publish the results of worksite studies in trade magazines and management publications to reach the level of management decision-makers. Illustrate the effectiveness of using worker participation programs, such as the Ergonomic Task Force, for introducing ergonomic changes that have successfully reduced the incidence of musculoskeletal injuries.

B. Recommendations to be Implemented in the Near Future

1. Training/Education

Seek assistance from the National Research Council's National Academy of Engineers to develop and promote curricula in occupational ergonomics and biomechanics for schools of engineering.

2. Surveillance Function

Establish official communication channels with state and federal agencies that gather data to encourage more active collection and identification of data on musculoskeletal health and injury, reflecting long-term as well as short-term effects. Collaborate with state and local occupational health and safety experts to conduct periodic ergonomic-hazard evaluations suitable for assess-

ing emerging health effects stemming from new computer-based technology (e.g., robots, electronic office operations). Consider small grants to state and local health offices to provide training and staff assistance.

3. Prevention/Specifications

   Involve the Institute of Industrial Engineers, industrial hygiene organizations, and equipment manufacturers in the development and testing of specifications for cumulative trauma control through the use of ergonomic tool design.

4. Prevention/Control

   Use the proposed National Committee on Musculoskeletal Diseases or a subcommittee to coordinate active participation with OSHA, the Mine Safety and Health Administration, the American Industrial Hygiene Association, and state health and industry departments in formulating ergonomic control guidelines for biomechanical stress associated with musculoskeletal injuries.

5. Education/Dissemination

   Establish a national clearinghouse of information on work-related musculoskeletal injuries to monitor industrial and technological developments that pose new or modified risks of such problems.

6. Dissemination/Awareness

   Seek active participation with the Office of Disease Prevention and Health Promotion in the Department of Health and Human Services and with local and regional state health agencies to improve public and private awareness of the causes and control of musculoskeletal injuries in the workplace. This could be accomplished by public service announcements on television and radio to describe the occupational hazards that pose risks for the back, legs, and wrists.

7. Consensus Standards

   Encourage special-interest groups concerned with the rising costs of musculoskeletal injuries and standard-setting groups, such as the American National Standards Institute, to participate in the development of consensus standards applicable to the engineering control of biomechanical stress.

8. Standards Evaluation

   Request the proposed National Committee on Musculoskeletal Diseases to evaluate the benefits of adopting a national ordinance or a generic standard similar to the Swedish ordinance (AFS 1983:6, "Working Postures and Working Environments") for controlling biomechanical hazards to the musculoskeletal system.

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